

DOCKET NO: 268510US0PCT

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF :  
BERND ZASCHKE, ET AL. : EXAMINER: COONEY, JOHN M.  
SERIAL NO: 10/530,707 :  
FILED: APRIL 8, 2005 : GROUP ART UNIT: 1765  
FOR: METHOD FOR PRODUCING RIGID :  
POLYURETHANE FOAMS BY MEANS  
OF GRAFT POLYHYDRIC ALCOHOLS

APPEAL BRIEF

SIR:

The following is an appeal of the examiner's final rejection of November 1, 2010 of claims 1-5, 7, 8, 10-12, 17 and 18 as obvious. A Notice of Appeal was timely filed on March 1, 2011.

(i) Real Party In Interest

The real party in interest is BASF SE, formerly BASF Aktiengesellschaft, by assignment recorded at reel/frame 016486/0992-94.

(ii) Related Appeals And Interferences

Appellants, appellants' legal representative and the assignee are not aware of any related appeals and interferences which will directly affect or be directly affected, or have a bearing on the Board's decision in the pending appeal. Any copies of decisions rendered by a court or the Board, if any, in any proceeding identified would be attached as related proceedings

appendix (x).

(iii) Status Of Claims

Appellants' state the status of all the claims in the proceeding as follows:

Claims 1-5, 7-8, 10-12, 17 and 18 are rejected and active in this application and are herein appealed.

No claims have been identified as allowed or confirmed.

No claims have been identified as withdrawn.

No claims have been identified as objected to.

Claims 6, 9, 13-16 and 19 have been canceled.

(iv) Status Of Amendments

No claim amendment subsequent to final rejection are sought. A copy of the claims herein appealed is attached as appendix (viii).

(v) Summary Of Claimed Subject Matter

The claimed invention is directed to a process for producing closed-celled rigid polyurethane foams by reacting (page 2, lines 34-35)

- a) crude MDI having an NCO content of from 29 to 33% by weight and a viscosity at 25°C in the range from 150 to 1000 mPa•s with (page 8, lines 33-36)
- b) compounds having at least two hydrogen atoms reactive toward isocyanate groups, in the presence of (page 2, lines 39-40)

c) catalysts, and (page 2, line 43)

d) blowing agents, (page 2, line 44)

which comprises the presence, among the compounds having at least two hydrogen atoms reactive toward isocyanate groups, of at least one graft polyol, (page 3, lines 1-3)

wherein said closed-celled rigid polyurethane has a proportion of closed cells in the foam of at least 88% (page 3, lines 7-10)

wherein said graft polyol is prepared by in-situ polymerization of ethylenically unsaturated monomers in polyether alcohols having a functionality of from 2 to 8 and having a hydroxy value in the range from 100 to 800 mg KOH/g, obtained by an addition reaction of alkylene oxides onto H-functional starter substances, the starter substances having been selected from the group consisting of polyfunctional alcohols, sugar alcohols, aliphatic amines, and aromatic amines (page 6, lines 19-25).

Rigid polyurethane foams having a closed-cell structure are known for thermal insulation. Reduced **molding times** and good **mold flow properties** are still sought in closed-celled rigid polyurethane foam producing processes.

The claimed invention addresses this problem by providing a process for preparing **rigid** closed-cell polyurethane foam comprising reacting polyisocyanate with a compound having at least two reactive hydrogen atoms in the presence of catalyst and a blowing agent, wherein the compound having at least two hydrogen atoms comprises **at least one graft polyol** having a **hydroxyl value of from 100 to 800 mg KOH/g**. Appellants have discovered that such a graft polyol provides for good properties in the process for producing a closed-celled **rigid** polyurethane foam and is able to provide for crosslinking densities of the polyurethane

network, which are higher than when using graft polyols based on flexible foam carrier polyols (pg 6, lines 33-35 of appellants' specification). Such a process is nowhere disclosed or suggested in the cited art of record.

Claim 1 is the only independent claim involved in this appeal, whose subject matter is defined above.

No means plus function or step plus function as permitted by 35 U.S.C. 112, sixth paragraph are used and therefore none are identified.

(vi) Grounds Of Rejection To Be Reviewed On Appeal

1) The rejection of claims 1-5, 7, 8, 10-12, 17 and 18 under 35 U.S.C. §103(a) in view of Haider et al. U.S. 2004/0014828, in view of Matsumoto et al. U.S. 6,117,937 in view of EP 786,480 is presented for review.

(vii) Argument

The examiner has committed reversible error in concluding the claimed invention to be obvious over the cited references as there is no motivation to combine the polymer polyol of Matsumoto et al with the rigid polyurethane of Haider et al. and none of the cited art of record discloses or suggests an enhancement in compressive strength with improved demoulding properties in a process of producing a closed-cell **rigid** polyurethane foam with a graft polyol having a hydroxyl value of from 100 to 800 mg KOH/g.

Haider et al. describes a closed-cell water-blown **rigid** polyurethane in which the polyol mixture comprises i) at least one polymer polyol, ii) at least one polyol having a hydroxyl value

of from about 200 to about 800, and iii) optionally at least one polyol having a hydroxyl value ranging from about 25 to about 115 (see abstract). Reduced friability, substrate adhesion, and compressive strength are goals of this foam (paragraph [0001]). The rigid foams are useful as insulating agents (paragraph [0002]). **Polymer** polyols are described in paragraph [0011] as including PHD polymer polyols and SAN polymer polyols having low hydroxyl values, but none having a hydroxyl value of from 100-800 as claimed.

In contrast, the claimed invention is directed to a process for producing closed-celled rigid polyurethane foams by reacting a graft polyol having a hydroxyl value of from 100 to 800 mg KOH/g. The claims recite **a hydroxyl value of from 100 to 800 mg KOH/g**. As the cited reference only discloses polymer polyol having a hydroxyl value of from 15 to about 50, a graft polyol having a hydroxyl value of from 100 to 800 mg KOH/g would simply not have been obvious. The claimed invention is clearly not rendered obvious from this reference.

The basic deficiency of the primary reference is not cured by either of the secondary references, as neither suggests using a graft polyol having a hydroxyl value of from 100 to 800 mg KOH/g in the preparation of a closed-cell **rigid polyurethane**.

Mastsumoto et al. has been cited for a disclosure of a polymer polyol having a hydroxyl value 600 mg KOH/g (paragraph column 4, lines 37-41). The reference seeks a flame retardant polyurethane resin and foam (column 1, lines 10-15). The polymer polyol, when used to prepare **flexible** polyurethane foams imparts an increased open cell content, and improves the indentation hardness of the foam (column 1, lines 23-26). The reference is directed to preparation of **a flexible polyurethane foam** (column 1, lines 23-26) and **not** to a closed cell **rigid** polyurethane foam.

The object of the invention is to provide **polymer dispersed polyol** which has an effect as **a raw material of flame retardant polyurethane** having excellent humid aged compression set and other durability, the preparation process of the same, and flame retardant polyurethane resin and flame retardant polyurethane foam which are prepared from the same. (column 2, lines 26-32, emphasis added)

However the flame retardant polyurethane of Matsumoto et al. is an open cell, flexible polyurethane foam.

Particularly when polymer dispersed polyol is used for **preparing flexible polyurethane foam**, effects such as increase in open cell content and improvement in indentation hardness can be obtained on the resultant foam. (column 1, lines 23-26)

Thus, the polyol of Matsumoto et al. is used in the preparation of **flexible** polyurethane foams, and has been selected for its ability to provide such a **flexible** flame retardant polyurethane foam with excellent humid aged compression set and other durability. Clearly the value of the polymer polyol of Matsumoto et al. is for the properties it confers to **a flexible polyurethane foam**.

Appellants respectfully submit that those of ordinary skill in the art draw a distinction between rigid and flexible polyurethanes foams and the polyols used to prepare same.

Typically, rigid polyurethane foams are obtained by reacting polyol components having a higher functionality and a shorter chain length as compared with polyether polyols used for polyurethane flexible foams. This arises in a higher hydroxyl value for rigid foam polyols, in which the hydroxyl value is from 350 to 650. As evidence of the hydroxyl value of conventional polyols used in a rigid polyurethane foam, appellants have previously submitted a passage from "Polyurethane Handbook, Edited Guenther Oertel, 2<sup>nd</sup> Edition"(1994), p 248.

Thus, when Haider et al. states that “Any polymer polyol known **in the art** can be used as component i)...”(paragraph[0011]), the “art” he is referring to is the art of closed-cell rigid water-blown polyurethane foams. While the term “art” is not defined, it could most broadly mean the art of all of technology or the art of closed-cell rigid water-blown polyurethane foams. There is no basis to specifically limit the term ‘art’ to that of polyurethane foams.” Thus, since interpretation of the term “art” to comprise all of technology would be absurd, the only reasonable and supported interpretation of the term “art” would be that of closed-cell rigid water-blown polyurethane foams, the area of technology to which Haider et al. pertains.

As a polyol for a **flexible polyurethane foam**, one of ordinary skill in the art would not be motivated to use such a polyol to prepare the **rigid polyurethane** of Haider et al. While the official action suggests motivation to use the polyol of Matsumoto et al. in the Haider et al. polyurethane in order to impart a compression and durability enhancing effect, such analysis ignores the fundamental differences between the polyurethane materials being prepared as **rigid v flexible**. The examiner has committed reversible error by ignoring the art recognized distinctions between rigid and flexible foams. Accordingly the combination of references fails to render the claimed invention obvious.

Moreover, appellants observe an enhancement in compressive strength with improved demoulding properties when using a graft polyol having a hydroxyl number of from 100-800 mg KOH/g.

As evidence of such an enhancement in compressive strength appellants have previously submitted the declaration of Dr. Andreas Emge, a named inventor of the above-identified application.

Dr. Emge tested the compressive strength, demoulding thickness, thermal conductivity and flowability for three rigid polyurethane foams, Example 1, containing no graft polyol, Example 2 containing a graft polyol having a hydroxyl number of only 36 mg KOH/g and example 3 having a graft polyol having a hydroxyl number of 160 mg KOH/g according to the claimed invention. For the examiner's convenience a portion of the data is again reproduced below:

	Example 1 Reference	Example 2	Example 3
Sucrose/glycerine-PO polyol, hydroxyl Number 450 mg KOH/g	48	48	48
TDA-EO-PO polyol, Hydroxyl Number 400 Mg KOH/g	30	30	30
TMP-PO polyol, Hydroxyl number 160 mg KOH/g	16	-	-
Graftpolyol 1	-	16	-
Graftpolyol 2	-	-	16
Catalyst package	2.1	2.1	2.1
Tegostab B8462	1.9	1.9	1.9
Water	2.3	2.3	2.3
Cyclopentane (70%) isopentane (30%)	13	13	13
Gel time [s]	39	36	35
Free rise density [g/l]	24.4	23.4	23.5
Polyol Viscosity [mPas]	6900	15700	12000
Compressive strength, foam sample 15% overpack [N/mm <sup>2</sup> ]	15.5	14.8	16.3
Demoulding thickness (after 3 min, 15% overpack ) [mm]	94.8	93.3	93.9
Thermal conductivity [mW/mK]	19.7	19.6	19.2
Flowability	1.31	1.34	1.36

Each of examples 2 and 3 containing a graft polyol demonstrated an improved demoulding property by about 1 mm as compared with Example 1 containing no graft polyol. A higher moulding thickness results in a higher cycle time and therefore slower processing.



However, compressive strength as measured according to DIN 53421/DIN EN ISO 604) for example 2 containing a graft polyol similar to that of Haider et al displayed a slightly deteriorated compressive strength as compared with example 1, while example 3 prepared with a graft polyol having a hydroxyl number of 160 mg KOH/g had an improved compressive strength. Thus by selection of a graft polyol having a hydroxyl number of from 100 to 800 mg KOH/g, appellants are able to realize a faster processing in terms of reduced demoulding thickness and an enhancement in compressive strength. Such a result is nowhere disclosed or suggested from the cited combination of references.

Further more, there would have been no expectation of enhancing the demoulding thickness and compressive strength by using the polyol of Matsumoto et al. in the process of Haider et al. for preparing closed cell rigid polyurethane, since the polyol of Matsumoto et al. is used to prepare a flexible polyurethane foam having a open cell structure (column 2, lines 26-32 and column 12, lines 55-57). There would have been no expectation of enhancing the demoulding thickness and compressive strength by using the polyol of Matsumoto et al. in the preparation of a closed cell rigid polyurethane foam.

While page 6 of the official action asserts that the data has not persuasively demonstrated unexpected results for the combination as claimed, appellants note that the enhancements in demoulding thickness of 93.3 mm and 93.9 mm for examples 2 and 3 as compared with 94.8 mm for example 1 reference is a 32% improvement. Such an enhancement would allow a manufacture to **decrease the cycle time** and therefore increase productivity of production of foamed articles. Such an increase in productivity without compromising other

foam parameters represents a significant improvement in closed-cell rigid polyurethane foam processing technology.

In support of the significance of appellants' demonstrated improvement is demoulding thickness, appellants previously submitted the opinion declaration of Dr. Marc Fricke, a researcher with BASF Polyurethanes GmbH, a subsidiary of the assignee BASF AG, now BASF SE. In Dr. Fricke's opinion, the evidence provided in the Emge declaration of January 7, 2010 provided evidence of a significant enhancement in a process for producing a closed-cell rigid polyurethane foam.

As the cited combination of references fails to disclose or suggest an enhancement in demoulding thickness and compressive strength in a process in which a graft polyol having a hydroxyl value of 100 to 800 mg KOH/g is used in the preparation of a closed cell rigid polyurethane foam, the claimed invention would not have been obvious. The decision of the examiner must be reversed.

Application No. 10/530,707  
Appeal of Office Action of November 1, 2010

In view of the errors committed by the examiner, his conclusion of obviousness is in error and must be reversed.

Respectfully submitted,

OBLON, SPIVAK, McCLELLAND,  
MAIER & NEUSTADT, L.L.C.



---

Richard L. Chinn, Ph.D.  
Registration No. 34,305

Customer Number  
**22850**

Tel: (703) 413-3000  
Fax: (703) 413 -2220  
(OSMMN 06/04)  
RLC:smi

(viii) Claims Appendix

Claim 1. A process for producing closed-celled rigid polyurethane foams by reacting

- a) crude MDI having an NCO content of from 29 to 33% by weight and a viscosity at 25°C in the range from 150 to 1000 mPa•s with
- b) compounds having at least two hydrogen atoms reactive toward isocyanate groups, in the presence of
- c) catalysts, and
- d) blowing agents,

which comprises the presence, among the compounds having at least two hydrogen atoms reactive toward isocyanate groups, of at least one graft polyol, wherein said closed-celled rigid polyurethane has a proportion of closed cells in the foam of at least 88%

wherein said graft polyol is prepared by in-situ polymerization of ethylenically unsaturated monomers in polyether alcohols having a functionality of from 2 to 8 and having a hydroxy value in the range from 100 to 800 mg KOH/g, obtained by an addition reaction of alkylene oxides onto H-functional starter substances, the starter substances having been selected from the group consisting of polyfunctional alcohols, sugar alcohols, aliphatic amines, and aromatic amines.

Claim 2. A process as claimed in claim 1, wherein the amount used of the graft polyol is up to 100% by weight, based on component b.

Claim 3. A process as claimed in claim 1, wherein the amount used of the graft polyol is from 0.5 to 70% by weight, based in each case on component b.

Claim 4. A process as claimed in claim 1, wherein the amount used of the graft polyol during the production of rigid polyurethane foams for use in refrigeration equipment is from 3 to 70% by weight, based on component b.

Claim 5. A process as claimed in claim 1, wherein the amount used of the graft polyol during the production of rigid polyurethane foams for use in sandwich components is from 0.5 to 35% by weight, based on component b.

Claim 7. A process as claimed in claim 1, wherein the graft polyol particle distribution has a maximum at from 0.1 to 8  $\mu\text{m}$ .

Claim 8. A process as claimed in claim 1, wherein the graft polyol has a bimodal particle size distribution.

Claim 10. A process as claimed in claim 1 wherein the graft polyol is prepared by in-situ polymerization of ethylenically unsaturated monomers in polyether alcohols which are obtained by an addition reaction of alkylene oxides onto tolylenediamine, using basic catalysis.

Claim 11. A process as claimed in claim 1, wherein the graft polyol is prepared by in-situ polymerization of ethylenically unsaturated monomers in polyether alcohols which are obtained by an addition reaction of alkylene oxides onto trimethylolpropane, using basic catalysis or catalysis by multimetal cyanide complexes.

Claim 12. A rigid polyurethane foam produced by the process of claim 1.

Claim 17. The process of claim 1, wherein said closed-celled rigid polyurethane has a proportion of closed cells in the foam of at least 95%.

Claim 18. The process of claim 1, wherein said graft polyol is prepared via in-situ polymerization of ethylenically unsaturated monomers in polyether alcohol.

(ix) Evidence Appendix

Declaration of Dr. Andreas Emge January 7, 2010

Declaration of Dr. Marc Fricke August 27, 2010

Polyurethane Handbook, Edited Guenther Oertel, 2<sup>nd</sup> Edition (1994), p 248

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

In re Application of

Bernd Zschke et al.

Serial Number 10/530,707

Filed: April 8, 2005

For: Method Producing Rigid Polyurethane Foams By Means Of Graft Polyhydric Alcohols

D E C L A R A T I O N   U N D E R 37 C F R 1.132

I, Andreas Emge, a citizen of the Federal Republic of Germany and residing at 49448 Lemförde, Federal Republic of Germany, declare as follows:

I am a fully trained chemist, having studied chemistry at the University of 97074 Wuerzburg, Federal Republic of Germany , from 1990 to 1996 and at the University of 89081 Ulm, Federal Republic of Germany , from 1996 to 1998.

I received my Doctors degree at the University of Ulm in 1998,

I joined Elastogran GmbH, 49448 Lemfoerde, Federal Republic of Germany, in 1999, since when I have been working in the field of polyurethane research and development,

I am well acquainted with technical English,



To demonstrate the advantages of the graft polyols according to the claims the above patent application and graft polyols as described in document US 2004/00114828 (Haider et al.) we made the following experiments:

We have prepared 3 polyurethane rigid foams.

All foams were made with the same catalyst package (53% Lupragen N100, 21% Lupragen N600, 26% Jeffcat PMDETA).

In Example 1 no graft polyol was used. In Example 2 graft polyol 1 based on a carrier polyol prepared by reaction of glycerin with propylene oxide and then ethylene oxide having an OH-number of 36 mgKOH/g had been used. The solid content (67% styrene, 33% acrylonitrile) was 44%. This polyol is very similar to polymer polyol C in US 2004/00114828 (Haider et al.)

In Example 3 graft polyol 2 based on a carrier polyol prepared by reaction of ethylene oxide and propylene oxide with vicinal TDA with an OH-number of 160 mg KOH/g had been used. The solid content (67% styrene, 33% acrylonitrile) was 45%.

The exact formulation is described below.

	Example 1 Reference	Example 2	Example 3
Sucrose/glycerine-PO polyol, Hydroxyl Number 450 mgKOH/g	48	48	48
TDA-EO-PO polyol, Hydroxyl Number 400 mgKOH/g	30	30	30
TMP-PO polyol, Hydroxyl Number 160 mgKOH/g	16		
Graftpolyol 1		16	
Graftpolyol 2			16
Catalyst package	2.1	2.1	2.1
Tegostab B8462	1.9	1.9	1.9
Water	2.3	2.3	2.3
cyclopentane (70%) / isopentane (30%)	13	13	13
Gel time [s]	39	36	35
Free rise density [g/l]	24.4	23.4	23.5
Polyol Viscosity [mPas]	6900	15700	12000
Compressive strength, foam sample 15% overpack [N/mm <sup>2</sup> ]	15.5	14.8	16.3
Demoulding thickness (after 3 min, 15% Overpack) [mm]	94.8	93.3	93.9
Thermal conductivity [mW/mK]	19.7	19.6	19.2
Flowability	1.31	1.34	1.36

Main results of this comparison are:

- Both graft polyols 1 and 2 lead to improved demoulding properties by about 1 mm. The demoulding is a rate for the cycle time for manufacturing the polyurethane foam. A higher demoulding thickness means that the cycle time is higher.
- The compressive strength (measured according to DIN 53421 / DIN EN ISO 604) of the foams prepared with graft polyol 1 (which is similar to Haider et al.) is slightly deteriorated compared to a reference foam whereas graft polyols 2 leads to an improved compressive strength.
- Other properties such as thermal conductivity and flowability are similar for all foams.

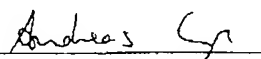
The polymer polyols used in US6117937 (Matsumoto et al.) are made with a carrier polyol prepared by reaction of glycerin with propylene oxide and then ethylene oxide having an OH-number of 33 mgKOH/g (polyol A). The only polymer polyol based on styrene/acrylonitrile particles is comparative example 2 (70% styrene, 30% acrylonitrile, solid content 20%). These polymer polyols are very similar to Haider's as they are using a typical flexible foam carrier polyol. Thus an expert would expect a similar performance of Matsumoto's polyols as in example 2 in our experiments.

This advantage of the graft polyols of our patent application could not be expected by the person skilled in the art.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information or belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signed at 49448 Lemförde, Germany, this

7<sup>th</sup> day of January 2010

  
Signature of Declarant

## IN THE UNITED STATES PATENT &amp; TRADEMARK OFFICE

In re Application of  
Bernd Zaszke et al.  
Serial Number 10/530,707  
Filed: April 8, 2005  
For: Method Producing Rigid Polyurethane Foams By Means Of Graft Polyhydric Alcohols

## DECLARATION UNDER 37 CFR 1.132

I, Marc Fricke, a citizen of the Federal Republic of Germany and residing at 49090 Osnabrueck, Federal Republic of Germany, declare as follows:

I am a fully trained chemist, having studied chemistry at the University of 33619 Bielefeld, Federal Republic of Germany, from 1994 to 2000.

I received my Doctors degree at the University of Bielefeld in 2004 with summa cum laude.

I joined BASF Polyurethanes GmbH, 49448 Lemförde, Federal Republic of Germany, in 2007, since when I have been working in the field of polyurethane research and development.

I am well acquainted with technical English.

In the Declaration regarding the above-mentioned patent application of January 7, 2010 Dr. Emge showed the difference between polyurethane rigid foams according to the above-mentioned patent application compared to polyurethane rigid foams manufactured in absence of graft polyols. The examples showed an improvement in the demoulding thickness of the foams manufactured in accordance to the above-mentioned patent application. The demoulding thickness is an important parameter for the manufacturing of polyurethane foams. It indicates how fast a foam part can be demoulded and therefore how many parts can be produced in a given time. As lower the demoulding thickness as faster a foam part can be demoulded and as more parts can be produced.

A mould of dimensions 40 cm \* 70 cm \* 90 cm was filled with the reaction mixture according to the table. The foamed parts were removed from the mould after a mould dwell time of 3 min, and their after swelling (demoulding thickness) was determined 24h after removal from the mould.

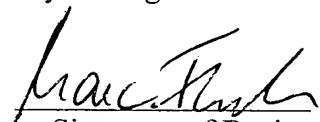
Therefore, an after swelling of about 3,3 mm compared to 4,8 mm in the reference is an improvement of 32%. The manufacturer would be able to decrease the cycle time and consequently, produce more parts in the same time.

In summary, Example 2 and 3 show an improved demoulding thickness (after swelling) compared to the reference without compromising other foam parameters.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information or belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signed at 49448 Lemförde, Germany, this

5<sup>th</sup> day of August 2010

  
Signature of Declarant

# Polyurethane Handbook

Chemistry – Raw Materials – Processing  
Application – Properties

Edited by Günter Oertel

2nd Edition

**BASF Aktiengesellschaft**  
**Patente, Marken u. Lizenzen**

With contributions from

L. Abele, Dr. G. Avar, Dr. A. Awater, Dr. G. Baatz, R. Bock, H. Boden,  
Dr. M. Dahm, Prof. Dr. D. Dieterich, Prof. Dr. W. Diller, Dr. M. Dollhausen,  
H.-A. Ehlert, Dr. J. Franke, Dr. A. Freitag, Dr. H. Gall, Z. Galler,  
H. Grammes, Prof. Dr. E. Grigat, Dr. P. Gupta, Dr. P. Haas, Dr. W. Hahn,  
Dr. K.-H. Hentschel, Dr. H. Hespe, J. Hoffmann, H.-G. Hoppe,  
Prof. Dr. R. Hoscheid, Dr. H. W. Illger, M. Jokel, Dr. M. Kapps, Dr. M. Kausch,  
Dr. H. Kleimann, Dr. U. Knipp, D. Krettek, N. Künstler, Dr. H. Lüdke,  
Dr. U. Maier, Dr. M. Mann, Dr. H. J. Meiners, Dr. F. Müller, Dr. H. Müller,  
Dr. G. Oertel, D. Pelzner, Dr. F. H. Prager, Dr. E. Ch. Prolingheuer,  
Dr. H. Rabe, Dr. K. Recker, Dr. W. Reichmann, Dr. H. Reiff, Dr. H. Rothermel,  
Dr. H. D. Ruprecht, H. I. Sachs, Dr. K. Schauerte, Dr. H. G. Schmelzer,  
Dr. H. G. Schneider, K. Schulte, Dr. P. Seifert, B. Stelte, R. Stoer,  
Dr. R. Sundermann, Dr. H. Thomas, Dr. H. Toepsch, Prof. Dr. H. Träubel,  
Dr. K. Uhlig, Dr. J. Vogel, U. Walber, Dr. R. Walter, Dr. Ch. Weber,  
Dr. E. Weigand, W. Wiczorrek, Dr. R. Wiedermann, Dr. K.-D. Wolf,  
Dr. H.-G. Wussow, Dr. R. Zöllner



Hanser Publishers, Munich

---

Hanser Gardner Publications, Inc., Cincinnati

## 6.1 Chemistry and Raw Materials

Dr. M. Kapps

The properties of polyurethane foams can be modified within wide limits depending on the raw materials used. This is also true for the area of rigid foams [2 to 4]. The density, flowability, strength, thermal stability, combustibility and other properties can be adjusted to suit the requirements of a given application. The polyols and isocyanates have a major impact on the properties of the foams. The versatility of raw materials and reactivities have led to a great variety of processes.

### 6.1.1 Polyols

Polyesters as well as polyethers can be used as polyols. Polyethers have good hydrolytic stability and are compatible with most formulation additives. High functionality polyether polyols with acceptable viscosities can also be produced. The commonly used rigid foam polyether polyols have OH-numbers from 350 to 650. The viscosities at 25°C range from 300 mPa·s to 35,000 mPa·s. Among other materials, glycols, glycerine, trimethylolpropane, sorbitol, sucrose, and aliphatic and aromatic amines are used to produce polyether polyols. Propylene oxide is the most commonly used alkylene oxide. Polyester polyols are made from phthalic acid, adipic acid, glycols, and glycerin among others. Foams based on polyester polyols have better combustibility properties and better thermal stability. We refer to subsection 2.2.2.

Most rigid foams are prepared from formulated blends. A blend consists of one or several polyols, a surfactant, a flame retardant and, if necessary, catalysts and a blowing agent. The formulation may also contain crosslinking agents, for example, triethanolamine or glycerin. They serve to improve curing and the strength of the foam.

### 6.1.2 Polyisocyanates

A general overview for polyisocyanates can be found in subsection 2.2.1. Isocyanates used for PU rigid foams are toluene diisocyanate (TDI) and polymeric diphenylmethanediisocyanate (polymeric MDI). TDI plays a minor role in polyurethane rigid foam. Because of more favorable physiological properties, variety and usability in many areas, polymeric MDI is currently the predominant isocyanate component for rigid foams.

Today different polymeric MDI types are available for various applications. When high priority is placed on flowability, e.g., when the expanding reaction mixture has to fill narrow gaps, low viscosity polymeric MDI's, with low functionality, are preferred. With increasing functionality and viscosity, the flowability is reduced. The use of these types of products is recommended to achieve increased thermal stability and improved combustibility properties. Using these higher functional types in the production of slabstock foam reduces the tendency to form splits and reduces the core discoloration. The cure time is decreased and the compressive strength and flammability of the finished foam are significantly improved. In the viscosity range of 50 to 2,000 mPa·s (25°C), the functionality varies from 2.5 to 3.2 (by the molecular weight method). As the functionality increases, the NCO content does not change significantly (32% at 50 mPa·s; 30% at 2,000 mPa·s; viscosity determined at 25°C). The use of modified polymeric MDI's is advantageous in foaming slabstock foams. Prepolymers with an NCO range between 25% and 29% are readily available and are therefore preferred. They mix easily with the polyol and they improve the flowability of the reaction mixture and the toughness of the end product. These advantages are especially utilized during the manufacture of isocyanurate modified foams because they tend to be more friable.

The Editor:  
Dr. Günter Oertel, Applications Research, Polyurethanes Division, BAYER AG Germany,  
51368 Leverkusen

Distributed in the USA and in Canada by  
Hanser Gardner Publications, Inc.  
6915 Valley Ave.  
Cincinnati, OH 45244, USA  
Fax: +1 (513) 527 8950  
<http://www.hansergardner.com>

Distributed in all other countries by  
Carl Hanser Verlag  
Postfach 860420, 81631 München, Germany  
Fax: +49 (89) 998 30-269  
<http://www.hanser.de>

The use of general descriptive names, trademarks, etc., in this publication, even if the former are not especially identified, is not to be taken as a sign that such names, as understood by the Trade Marks and Merchandise Marks Act, may accordingly be used freely by anyone.

While the advice and information in this book are believed to be true and accurate at the date of going to press, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

#### Library of Congress Cataloging-in-Publication Data

Polyurethane. English.

Polyurethane handbook / edited by Günter Oertel, with  
contributions from L. Abele ... [et al.]. – 2nd ed.  
p. cm.

Includes bibliographical references and index.

ISBN 1-56990-157-0

I. Polyurethanes – Handbooks, manuals, etc. I. Oertel, Günter.

II. Abele, L. (Lothar) III. Title.

TP1180.P8P5713 1993

668.4'239–dc20

93-33469

Die Deutsche Bibliothek – CIP-Einheitsaufnahme

Polyurethane handbook / ed. by Günter Oertel. With  
contributions from L. Abele ... – 2. ed. – Munich ; Vienna ;  
New York : Hanser ; Cincinnati : Hanser/Gardner  
Publ. 1993

Einheitssacht : Polyurethane <engl.>

ISBN 3-446-17198-3

NE: Oertel, Günter [Hrsg.]; Abele, Lothar [Mitverf.]; EST

All rights reserved. No part of this book may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying or by any information storage and retrieval system, without permission from the publisher.

© Carl Hanser Verlag, Munich, 1994

Printed and bound in Germany by Passavia Druckerei GmbH Passau

Application No. 10/530,707  
Appeal of Office Action of November 1, 2010

(x) *Related Proceedings Appendix*

none